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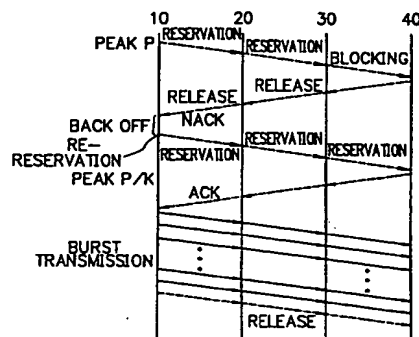
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(54) **Burst band-width reservation method in an asynchronous transfer mode (ATM) network.**

(57) In an ATM network using a burst-level band-width allocation, a source terminal reserves, before a burst transmission, band-widths according to a peak rate of the burst and then sends the burst therethrough. When the transmission is finished, the band-widths are released. Where there exists a link to which the peak rate is not assigned, NACK is sent to the terminal and the reserved band-widths are released. On receiving the NACK, the terminal allocates a band-width with peak rate lower than that of the first request after a back-off time is elapsed, thereby minimizing the block probability of the transmission. The source terminal declares a minimum band-width together with the peak rate (maximum band-width) in the band-width request operation. Each node allocates the peak rate when the remaining band-width of a link controlled by the node is sufficient to allocate the peak rate. Even if the remaining band-width is insufficient, when the band-width is not less than the minimum band-width, there is allocated a band-width equal to or more than the minimum band-width and equal to or less than the peak rate according to the remaining band-width, thereby transferring the burst.

FIG. 3



EP 0 609 654 A2

The present invention relates to a method of reserving burst band-widths or band-widths in an ATM network.

Description of the Related Art

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Heretofore, a congestion control method has been employed to detect a congestion in a network so as to prevent deterioration of the quality of network operation. For example, in "A Study on Congestion Control for Bit Rate Free ATM Network Resource Management", 1992 IEICE (Japan) Conference, SSE92-21, there has been described a technology in which an exchanger or a switching apparatus in a network detects a cell loss probability to decide a congested state of the network so as to control traffic therein according to the state of congestion. Namely, when the congestion is at a low level, the pertinent path is changed over to another path free of congestion; whereas, when the congestion is at a high level or heavy, the UPC of each switching facility disposed at an entrance of the network is restricted to limit the traffic of the network, thereby improving the cell loss probability in the network.

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In the congestion control method of the prior art, a switching device detects a cell loss probability to determine a congested state in the network. Consequently, the device is required to include means to detect the cell loss probability; moreover, there is necessitated means to decide one of the switching devices and to restrict the UPC thereof, thereby controlling the pertinent device.

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Furthermore, in order to restore the cell loss probability to the original appropriate value in the network, it is required to restrict the UPC of the pertinent switching apparatus at an entry of the network. In consequence, data resultant from the UPC restriction is not returned to the pertinent terminal and the traffic through the terminal is lost at the entry point of the network.

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Moreover, a conventional method of allocating band-widths for each burst has been described, for example, in the "Fast Band-width Reservation Scheme with Multi-path & Multi-link Routing in ATM Networks", Suzuki et al., 1991 IEICE (JAPAN) Conference, SSE91-112. According to this technology, to allocate a band-width to each burst level, a terminal notifies, before transmitting a burst, only a maximum band-width (peak rate) necessary for the burst transmission to the system. If the maximum band-width can be reserved for all links on a path, the burst is transmitted; otherwise, the burst transmission is blocked or inhibited.

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That is, as shown in Fig. 1, immediately before a burst transmission, the terminal reports a maximum band-width therefor. If the maximum band-width is reserved in all links of the path, the burst is transmitted. If the band-width reservation is impossible, the burst is prevented from being transmitted. In this connection, reference numerals 210, 220, 230, and 240 respectively designate nodes of the network in Fig. 1.

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However, the conventional method of allocating a burst band-width is attended with a problem when the load imposed on the ATM network becomes greater. Namely, when a request is issued with a high peak rate in such a situation, the probability of blockage thereof is increased and hence throughput of the ATM network is limited.

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It is therefore an object of the present invention to provide a congestion control method capable of removing the problems.

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Moreover, another object of the present invention is to provide a flexible method of reserving a band-width for a burst capable of flexibly reserving a band-width according to a maximum band-width and a minimum band-width requested for reservation and a remaining band-width of each link, thereby solving the problem.

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In accordance with the present invention, there is provided a burst band-width reservation method for use with an ATM network. The method includes the steps of connecting a source terminal via a plurality of nodes to a destination terminal, setting a path between an initiating node and a terminating node in a call set-up phase, reserving for each link on the path, prior to transmission of a burst from the source terminal, band-widths to send the burst therethrough, thereby transferring the burst, releasing the reserved band-widths after the burst is completely transmitted, repeatedly conducting by the source terminal, at a failure of the band-width reservation on the path, a band-width re-reservation until band-widths are successfully reserved, and counting by the source terminal the number of successively failed attempts of the band-width reservation, thereby minimizing a request band-width at the band-width re-allocation for the burst transmission in accordance with the number of successively failed attempts.

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The objects and features of the present invention will become more apparent from the consideration of the following detailed description taken in conjunction with the accompanying drawings wherein:

Fig. 1 is a schematic diagram showing a conventional method of reserving a band-width according to a burst level;

Fig. 2 is a diagram showing a network configuration to which the present invention is to be applied;

Fig. 3 is a diagram for explaining congestion control operations in a band-width reservation and a re-reservation of a band-width in a first embodiment in accordance with the present invention;

Fig. 4 is a diagram showing an example of status transition of the peak rate in a second embodiment according to the present invention;

5 Fig. 5 is a diagram showing another example of status transition of the peak rate in a second embodiment in accordance with the present invention;

Fig. 6 is a diagram useful to explain congestion control operations in a band-width reservation and a re-reservation of a band-width in a third embodiment according to the present invention;

10 Fig. 7 is a diagram showing a congestion control operation in a fourth embodiment in accordance with the present invention;

Fig. 8 is a diagram showing an ATM network to which the present invention is to be applied;

Fig. 9 is a diagram for explaining a burst-level band-width reservation in a fifth embodiment according to the present invention;

15 Fig. 10 is a diagram useful to explain a burst-level band-width reservation in a sixth embodiment in accordance with the present invention;

Fig. 11 is a diagram useful to explain a burst-level band-width reservation in a seventh embodiment in accordance with the present invention;

Fig. 12 is a network diagram for explaining an eighth embodiment according to the present invention;

20 Fig. 13 is a diagram useful to explain an example of the burst-level band-width reservation in the eighth embodiment in accordance with the present invention; and

Fig. 14 is a diagram useful to explain another example of the burst-level band-width reservation in the eighth embodiment according to the present invention.

Fig. 2 shows an example of an ATM network to which the present invention is to be applied. In this diagram, there is shown a virtual channel (VC) to transfer a burst from a source terminal 80 to a destination terminal 90. Reference numerals 10 to 70 respectively denote nodes of the ATM network. Between the
25 respective adjacent nodes 10 and 20, 20 and 30, 30 and 40, 10 and 70, 60 and 70, and 40 and 60, there are established links 1 to 6, respectively. In this regard, the virtual channel includes a path 10-20-30-40 (i.e., a path passing the nodes 10 to 40 in this order) and links 1, 2, and 3 therebetween.

Fig. 3 shows an example of congestion control operations accomplished to reserve band-widths for
30 each burst transmission and to reserve again band-widths in the first embodiment according to the present invention. Prior to transmission of a burst, a reservation cell is sent from the node 10 to the node 40 to reserve band-widths. The band-width requested is a maximum band-width (peak rate) P. When there exist only insufficient band-widths remaining in the path and hence the reservation is rejected, a rejection signal NACK is sent to the transmission source terminal. In addition, to prevent occurrence of a deadlock in the
35 system, a band-width of each intermediate link already reserved is released. When a back-off period of time is elapsed thereafter, the source side conducts the reservation again. In this case, to reduce the blockage probability of reservation, when NACK is received N times (N is a predetermined number), the terminal lowers the request band-width to P/k . This operation is repeatedly accomplished until the band-width is successfully reserved. In Fig. 3, there is shown a case where N is set to one. Namely, when NACK is once
40 received, the terminal modifies the peak rate from P to P/k for the subsequent reservation. The value of k is predetermined in the system. When the reservation is successfully completed, an acknowledge signal ACK is transmitted to the source terminal. In response thereto, the source terminal sends the burst to the destination terminal. After the burst transmission is successfully terminated, a cell indicating the termination is sent to release the reserved band-widths.

45 Fig. 4 shows an example of state transition in the peak rate alteration according to a second embodiment of the present invention. In the diagram, the peak rate takes two values P1 and P2 and the values of N1 and N2 are one and five, respectively.

Before sending a burst, to reserve band-widths, a reservation cell is transmitted from the node 10 to the node 40. The request band-width is set to the maximum band-width (peak rate) P1. If the remaining band-
50 widths are insufficient and hence the request for reservation is blocked, NACK is returned to the transmission side. Moreover, to prevent the system deadlock, intermediate band-widths already reserved are released. After NACK is once received, the terminal lowers the peak rate from P1 to P2. Thereafter, the peak rate is set to P2 for the terminal to issue a reservation request for the transmission burst. This also applies to the subsequent retries for reservation of band-width. When ACK is successively received five
55 times, the peak rate is restored from P2 to P1. When NACK is received after three consecutive ACKs, the count value of ACKs is cleared to zero. Namely, the count value of the next ACK is assumed to be one such that when ACKs are successively received five times, the peak rate is first restored to P1.

In addition to Fig. 4 in which the peak rate takes two values, there is shown Fig. 5 in which the peak rate takes multiple values. In this case, after the peak rate is altered from P_1 to P_2 in response to N_1 NACK receptions, when NACKs are consecutively received N_1 times again, the peak rate is changed from P_2 to P_3 . Until ACKs are successively received N_2 times, the peak rate is decreased up to a minimum value P_n as above.

In Fig. 5, the peak rate P_n is varied to the next larger peak rate P_{n+1} when ACKs are consecutively received N_2 times, and the peak rate P_n is altered to the next smaller peak rate P_{n-1} when NACKs are successively received N_1 times. There may also be considered a method in which each of the values P_{n-1} and P_{n+1} is changed for each peak rate. Namely, these values are determined as follows for the respective changes, for example, N_2 is set to ten for transition from P_1 to P_2 , whereas N_2 is equal to five for alteration from P_2 to P_3 .

Fig. 6 shows an example of the congestion control operation in the band-width reservation and re-reservation for a burst transmission in a third embodiment according to the present invention. Like in the first embodiment, it is also assumed in the third embodiment that the remaining band-widths are insufficient such that the reservation is blocked and NACK is returned to the requesting side. Thereafter, when a back-off period of time T is elapsed, the requesting terminal achieves again the band-width reservation. When the reservation is unsuccessful and NACKs are received N times (N is a predetermined value), the back-off time is elongated to T^*K . This operation is repetitiously accomplished until the band-width reservation is successfully completed.

In Fig. 6, there is shown a case where the value of N is set to one. Namely, when NACK is once received after a failure of the first re-reservation, the back-off time is changed to T^*K (K is a predetermined value).

When the reservation is successfully terminated, ACK is transmitted to the requesting terminal. In response thereto, the terminal sends the burst to the destination. After the burst is completely transmitted, a cell reporting the termination of burst transmission is sent to release the reserved band-widths.

Fig. 7 shows an example of operation to control congestion in a fourth embodiment in accordance with the present invention. According to this method of the present invention, the peak rate is altered in a manner similar to that of the second embodiment in a network in which the band-width allocation is not conducted for each burst. In the fourth embodiment, when a cell is lost during a burst transmission and hence the transmission is failed, NACK is returned to the source terminal. In contrast thereto, when there does not occur such a cell loss and hence the burst transmission is successfully achieved, ACK is sent to the terminal. When NACKs are consecutively received N_1 times, an interval between transmission cells is increased to minimize the peak rate. When ACKs are successively received N_2 times, the interval between cell transmissions is decreased to set a greater value as the peak rate.

Fig. 7 shows a case where the values of N_1 and N_2 are set to one and two, respectively. When NACK is once received, the interval between cells transmitted from the terminal is multiplied by k to decrease the peak rate to P/k . Thereafter, when ACK is received twice, the interval is again reduced, namely, the value thereof is divided by k to restore the peak rate to P .

Also in the fourth embodiment, like in the second embodiment, the peak rate may take multiple values and the values respectively of N_1 and N_2 may be varied for each peak rate.

As described above, in accordance with the embodiments, the terminal includes means to detect loss of a band-width reservation cell and/or discarding or removal of a packet so as to determine a congestion of a network, thereby limiting the peak rate in the terminal. Namely, the terminal can achieve a congestion control independently of operation of the network while communicating with another terminal. In other words, the network is not required to conduct any congestion control functions for this purpose.

Fig. 8 shows an alternative example of an ATM network to which the burst band-width reservation method is applied in accordance with the present invention. The network includes a transmission source terminal 180, a destination terminal 190, a first path 17 and a second path 18 respectively therebetween, nodes 110 to 140 and links 11 to 13 for establishing the first path 17, nodes 110 to 160 and links 14 to 16 for configuring the second path 18. Each node includes an ATM switching device, a processor for controlling transfer of cells, and the like (details of the configuration are not shown). Since each of the links 11 to 16 is in a single-link structure in this case, one virtual channel is formed in each of the paths 17 and 18. In this regard, even if each of the paths and links is configured in a multiple path or link configuration, the present invention can be similarly implemented.

Referring now to Figs. 8 and 9, description will be first given of operation of the band-width reservation at each burst transmission in a fifth embodiment according to the present invention. Before a burst is sent from the terminal 180, to reserve band-width for the burst transmission, a reservation cell is sent from the terminal 180 to the node 110. The cell includes information denoting the maximum band-width (peak rate)

P1 and the minimum band-width P2. It is assumed that the values of P1 and P2 are set to 100 and 50, respectively. Moreover, it is assumed that the links 11 to 13 respectively controlled by the nodes 110 to 130 have remaining band-widths "150", "80", and "120", respectively. On receiving the reservation cell from the terminal 180, since the remaining band-width of the first link 11 is "150", the node 110 reserves the maximum band-width "100" for the transmission and then sends the cell to the node 120 controlling the second link 12. The remaining band-width of the node 120 is "80". Namely, this band-width is less than the maximum band-width "100" and is not less than the minimum band-width "50". Consequently, the remaining band-width "80" is reserved for the link 12 and then the cell is transmitted to the node 130. Since there is the remaining band-width equal to or more than the maximum band-width "100" for the third link 13, the node 130 reserves the maximum band-width "100" and then transmits the cell to the node 140. On receiving the cell, the node 140 recognizes according to information of the cell (indicating $P1 = 100$ and $P2 = 50$ sent from the initiating terminal 180 and the band-widths "100", "80", and "100" reserved by the respective nodes) that the band-widths have been reserved up to the last link 13. Resultantly, an ACK cell notifying the reserved minimum band-width "80" is sent via the nodes 130, 120, and 110 to the terminal 180. Receiving the ACK cell indicating the reservation of the band-width "80", the terminal 180 transmits the burst at the transmission rate "80". After the burst is completely transmitted therefrom, the terminal 180 releases the reserved band-widths.

In this connection, in a case where the remaining band-width is at most the minimum band-width "50" in either one of the links, the burst transfer is inhibited and an NACK cell is sent to the transmission source terminal 180. Furthermore, to avoid the deadlock state of the system, the band-widths already reserved for intermediate links related to the transmission are released. In this case, the terminal 180 carries out again the band-width reservation when the back-off time is elapsed thereafter. Each node can control the remaining band-width of the associated link according to a table.

Fig. 10 shows an example of operation to reserve band-widths for each burst transmission in a sixth embodiment according to the present invention. Like in the embodiment of Fig. 9, the sixth embodiment is implemented in the ATM network shown in Fig. 8. Prior to a transmission of a burst, to request a band-width reservation, the source terminal 180 sends a reservation cell to the node 110. As for the requested band-width, the maximum band-width P1 is "100" and the minimum band-width P2 is "50". The remaining band-widths of the links 11 to 13 are set as "150", "80", and "120", respectively. The node 110 reserves the maximum band-width "100" for the link 11. The remaining band-width of the second link 12 is "80", which is less than the maximum band-width "100" and is not less than the minimum band-width "50". Consequently, the node 120 reserves the remaining band-width "80". The remaining band-width of the link 13 is "120" or more, which is not less than the band-width "80" reserved for the link 12. In consequence, the node 130 reserves the band-width "80" for the third link 13. The node 140 recognizes according to the cell from the node 130 that the band-width reservation is completed up to the final link, thereby sending an ACK cell notifying the reserved band-width "80" via the nodes 130, 120, and 110 to the initiating terminal 180. When relaying the ACK cell, the node 110 excessively reserved the band-width releases the excess portion of band-width "20" and then updates the pertinent entry of the table such that the table indicates the reserved band-width "80". Operations thereafter are conducted in substantially the same manner as for the embodiment of Fig. 9.

Fig. 11 shows an example of operation of the band-width reservation at a burst transmission in a seventh embodiment according to the present invention. In the sixth embodiment of Fig. 10, in a case where each of the remaining band-widths is equal to or more than the minimum band-width and is not less than the maximum band-width, the maximum band-width is reserved. On the other hand, if each of the remaining band-widths is equal to or more than the minimum band-width and is less than the maximum band-width, the remaining band-widths are entirely reserved. In the seventh embodiment, however, a band-width obtained according to a function $f(P1, P2, C)$ is reserved to save the remaining band-widths to some extent, thereby lowering the block probability of burst transmission. As described above, like the embodiments above, the seventh embodiment is materialized for use with the ATM network of Fig. 8. For the links 11 to 13 of the virtual channel (VC) to transfer the burst from the initiating terminal 180 to the destination terminal 190, the remaining band-widths (C) are "150", "80", and "120", respectively. In this situation, the request band-width is calculated according to a function $f(P1, P2, C)$ with respect to the maximum request band-width or the band-width P1 allocated by a preceding node, the minimum request band-width P2, and the remaining band-width C of the pertinent link. In this embodiment, the function $f(P1, P2, C)$ is as follows.

$$f(P1, P2, C) = \begin{cases} P1 & C/2 > P1 \\ C/2 & P1 \geq C/2 \geq P2 \\ P2 & C/2 < P2 \\ 0 & C < P2 \end{cases}$$

10 Namely, for the link 11, the remaining band-width is "150" and hence $P1(100) > 150/2 > P2(50)$. In consequence, there is reserved $C/2 = 75$. For the link 12, the remaining band-width is "80" and hence $80/2 < P2(50)$; consequently, there is reserved $P2 = 50$. Moreover, the remaining band-width is "120" for the link 13 and the band-width reserved by the previous link is $P1 = 50 < C/2$. In consequence, $P1 = 50$ is reserved for the transmission. Like in the embodiment of Fig. 10, when the band-width reservation is completed up to the last link, and ACK cell containing the reserved band-width "50" is transmitted to the source terminal 180. In the repeating operation of the ACK cell, the node 110 having excessively reserved the band-width releases the excess band-width portion "25" and then updates the table to denote the reservation band-width "50". Operations thereafter are similar to those of the embodiments above.

As above, in accordance with the embodiments, even when the maximum band-width is missing in a link, if the remaining band-width is not less than the minimum band-width, there can be allocated a band-width thereto according to the remaining band-width. This resultantly reduces the block probability of burst transmission and hence increases the network utilization efficiency.

Fig. 12 shows an example of the ATM network to which an eighth embodiment is applied in accordance with the present invention. The network includes ATM nodes 110 to 160. Between the adjacent nodes 110 and 120, 120 and 130, 130 and 140, 140 and 150, 150 and 160, and 110 and 160, there are formed links 11 to 16, respectively. It is assumed that each link has a link band-width capacity "150", a virtual channel (VC) to transfer a burst from a transmission source terminal 180 to a destination terminal 190 includes a path 110-120-130-140 and links 11 to 13, and a virtual channel (VC) to transfer a burst from an initiating terminal 200 to a partner terminal 170 includes a path 160-110-120-130 and links 16, 11, and 12.

30 Figs. 13 and 14 schematically show examples of the congestion control operations in the band-width reservation and re-reservation of band-width for a burst transmission in the eighth embodiment according to the present invention.

Before transmitting a burst from the terminal 180 to the terminal 190, to issue a request for band-width reservation, a reservation cell is sent from the node 110 to the node 140. In the reservation, it is assumed that the remaining band-widths of the links 11 to 16 are "150", "150", "0", "0", "150", and "150", respectively.

The band-width requested by the terminal 180 is between the maximum band-width (peak rate) $P1$ and the minimum band-width $P2$. It is assumed that $P1$ and $P2$ take values "150" and "10", respectively. In this case, the remaining band-width of the link 13 is "0", namely, there is missing the remaining band-width $P2 = 10$ as the minimum band-width. Consequently, the reservation is rejected and a NACK cell is sent to the transmitting terminal 180 as shown in Fig. 13. In addition, to prevent the deadlock of the system, the band-widths already reserved for intermediate links are released. When the back-off time is elapsed thereafter, the initiating terminal 180 conducts the reservation again. In the operation of the terminal 180, to decrease the block probability of the burst transmission, when an NACK cell is received N times (N is a predetermined value), the maximum request band-width is lowered to $P1'$. In the diagram of Fig. 13, the values of $N1$ and $P1'$ are set to one and 75, respectively. Namely, when the transmission side receives an NACK cell once, the band-width reservation is conducted with the maximum band-width $P1'$ and the minimum band-width $P2$ set to 75 and 10, respectively. In an operation of the terminal 180 to reserve band-widths again, assume that communications from other terminals using the links 13 and 14 are completed and the remaining band-width is "150" for each link. Since each of the remaining band-widths of the links is more than the maximum band-width "75", the maximum band-width "75" is reserved for each link so as to initiate the burst transmission. In this situation, the remaining band-widths of the links 11 to 16 are "75", "75", "75", "150", "150", and "150", respectively.

Assume that a band-width reservation is requested by the terminal 200 using the links 16, 11, and 12 in this state. In a case where the reservation request is similarly issued with the maximum band-width $P1$ and the minimum band-width $P2$ set respectively to 150 and 10, since the remaining band-width of the link 16 is "150", an attempt is made to reserve the band-width "150". However, since the remaining band-width of the links 11 and 12 is "75", only the band-width "75" is reserved as shown in Fig. 14 and then an ACK cell

reporting the reservation of the band-width "75" is sent to the source terminal 180. In this case, the link 16 excessively reserved the band-width releases the excess band-width "75" and the reserved band-width is set to "75". On receiving the ACK cell, the terminal 180 initiates transmitting the burst at the peak rate "75". After the transmission is completed, a cell denoting the termination of the transmission is sent to release the reserved band-widths.

As above, the band-widths to be allocated are flexibly changed according to the remaining band-widths. This consequently lowers the block probability of the burst transmission.

In accordance with the present invention as described above, the maximum request band-width is reduced according to the number of failed attempts of band-width reservation. Moreover, even when there is missing the maximum band-width for a link, if the remaining band-width is equal to or more than the minimum band-width, there can be allocated a band-width for the transmission. Consequently, even in a network operated for an application fully using the link capacity to the maximum extent, the block probability of the burst transmission is minimized and the network utilization efficiency is improved.

While the present invention has been described with reference to the particular illustrative embodiments, it is not to be restricted by those embodiments but only by the appended claims. It is to be appreciated that those skilled in the art can change or modify the embodiments without departing from the scope and spirit of the present invention.

Claims

1. A burst band-width reservation method for use with an ATM network, comprising the steps of:
 - connecting a source terminal via a plurality of nodes to a destination terminal;
 - setting a path between an initiating node and a terminating node in a call set-up phase;
 - reserving for each link on the path, prior to transmission of a burst from the source terminal, band-widths to send the burst therethrough, thereby transferring the the burst;
 - releasing the reserved band-widths after the burst is completely transmitted;
 - repeatedly conducting by the source terminal, at a failure of the band-width reservation on the path, a band-width re-reservation until band-widths are successfully reserved; and
 - counting by the source terminal the number of successively failed attempts of the band-width reservation, thereby decreasing a request band-width at the band-width re-allocation for the burst transmission in accordance with the number of successively failed attempts.
2. A method as claimed in claim 1, further including the steps of:
 - calculating by the source terminal the number of consecutively succeeded attempts of the band-width reservation; and
 - decreasing by the source terminal a request band-width for the burst transmission from the source terminal in accordance with the number of consecutively succeeded attempts.
3. A method as claimed in claim 1, further including the steps of:
 - calculating by the source terminal the number of consecutively succeeded attempts of the band-width reservation; and
 - increasing a back-off period of time for the band-width re-reservation at a failed attempt of the band-width reservation in accordance with the number of successively failed attempts.
4. A method as claimed in claim 1, 2, or 3, wherein the source terminal includes:
 - means for repeatedly conducting, at a failure of the band-width reservation on the path, a band-width re-reservation until band-widths are successfully reserved;
 - means for counting the number of successively failed attempts of the band-width reservation; and
 - means for altering a request band-width, thereby decreasing the request band-width at the band-width re-allocation for the burst transmission in accordance with the number of successively failed attempts.
5. A method as claimed in claim 4, wherein the source terminal includes means for counting the number of consecutively succeeded attempts of the band-width reservation, thereby increasing the request band-width for the burst transmission from the source terminal in accordance with the number of consecutively succeeded attempts.

6. A method as claimed in claim 5, wherein the source terminal includes means for altering the back-off period of time for a re-reservation of a band-width at a failed attempt of the band-width reservation, thereby increasing the back-off period of time according to the number of succeeded attempts.
- 5 7. In an ATM network in which a source terminal is connected via a plurality of nodes to a destination terminal and a burst is transferred therethrough,
the source terminal decides at an occurrence of a loss of a burst cell in a burst transmission that the pertinent transmission has been failed and calculates the number of failed burst transmissions,
the source terminal decides when a cell transmission is achieved without any cell loss that the
10 transmission is successfully conducted and calculates the number of succeeded burst transmissions,
the source terminal increases an interval between cell transmissions in accordance with the number of failed burst transmissions, thereby decreasing a peak rate defined by the interval, and
the source terminal decreases the interval between cell transmissions in accordance with the number of succeeded burst transmissions, thereby increasing the peak rate.
- 15 8. In the AIM network as claimed in claim 7, the source terminal includes:
means operative at an occurrence of a loss of a burst cell in a burst transmission for deciding an event that the pertinent transmission has been failed;
means for calculating the number of failed burst transmissions;
20 means operative when a cell transmission is achieved without any cell loss that the transmission is successfully conducted;
means for calculating the number of succeeded burst transmissions; and
means for altering a peak rate defined by an interval of the transmitted burst cells,
the source terminal increasing the interval in accordance with the number of failed burst trans-
25 missions, thereby decreasing the peak rate,
the source terminal decreasing the interval between cell transmissions in accordance with the number of succeeded burst transmissions, thereby increasing the peak rate.
9. A burst band-width reservation method for use with an ATM network, comprising the steps of:
30 connecting a source terminal via a plurality of nodes to a destination terminal;
setting a path between an initiating node and a terminating node in a call set-up phase; and
reserving by the source terminal band-widths for all links on the path prior to transmission of a burst therefrom, transferring the burst therethrough to the destination terminal, and releasing the reserved band-widths after the burst is completely transmitted,
35 the band-width reservation being achieved by sending to the initiating node, prior to the burst transmission, a signal indicating a maximum band-width and a minimum band-width necessary for the burst transfer,
each node on the path reserving, according to the maximum band-width and the minimum band-width and a remaining band-width of a link managed by the node, a band-width equal to or more than
40 the minimum band-width and equal to and less than the maximum band-width according to the remaining band-width, the remaining band-width being equal to or more than the minimum band-width.
10. A method as claimed in claim 9, wherein each of a second and subsequent nodes on the path reserves in a manner similar to that of the first node a band-width equal to or more than the minimum band-
45 width and equal to and less than a band-width allocated by the previous node, the remaining band-width of a link controlled by the node being equal to or more than the minimum band-width.
11. A method as claimed in claim 10, wherein:
the first node on the path reserves a band-width obtained by a function $f(P1, P2, C)$ according to
50 the maximum band-width P1, the minimum band-width P2, and a remaining band-width of a link controlled by the node; and
each of the second and subsequent nodes on the path reserves in a manner similar to that of the first node a band-width obtained by a function $f(P3, P2, C)$ according to a band-width P3 allocated by a
previous node, the minimum band-width P2, and the remaining band-width C, the remaining band-width
55 C being equal to or more than the minimum band-width P2.
12. A method as claimed in claim 9, 10, or 11, further including the steps of:
repeatedly conducting by the source terminal, at a failure of the band-width reservation on the path,

EP 0 609 654 A2

a band-width re-reservation until band-widths are successfully reserved;

minimizing by the source terminal a request band-width at the band-width re-allocation in accordance with the number of failed attempts of band-width reservation; and

5 decreasing by the source terminal the request band-width at the band-width re-allocation for the burst transmission in accordance with the number of failed attempts and the remaining band-widths of the links until the band-width reservation is successfully achieved.

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FIG. 1
PRIOR ART

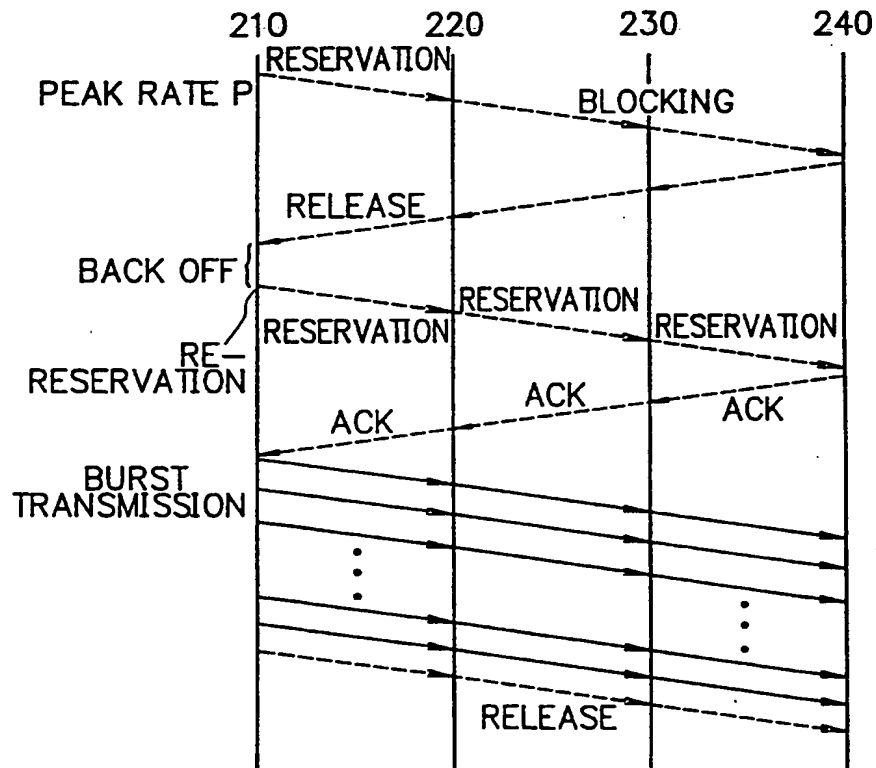


FIG. 2

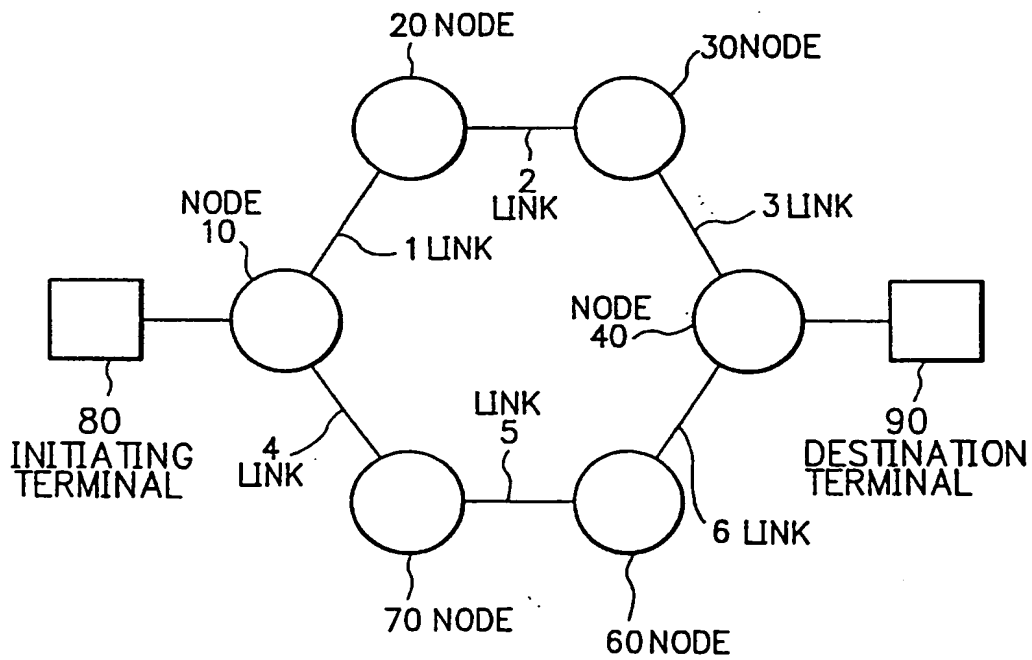


FIG. 3

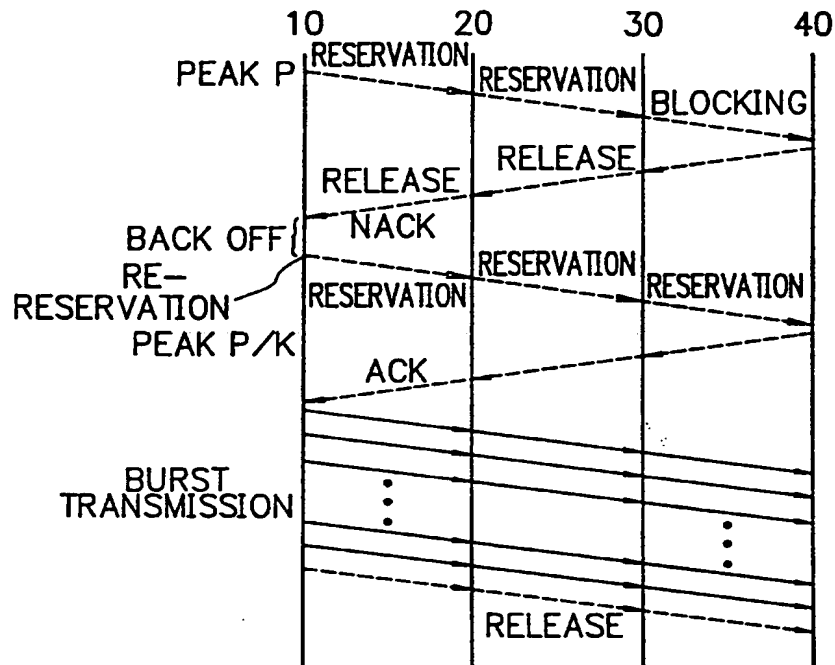


FIG. 4

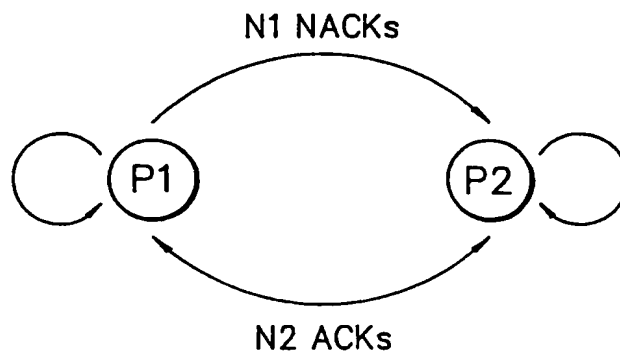


FIG. 5

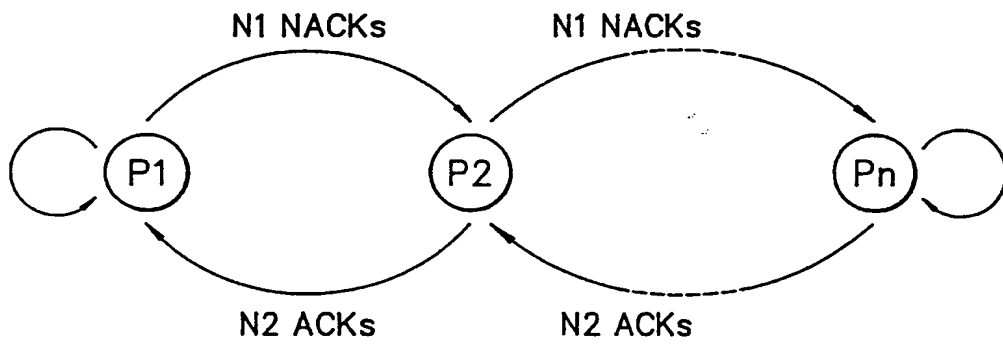


FIG. 6

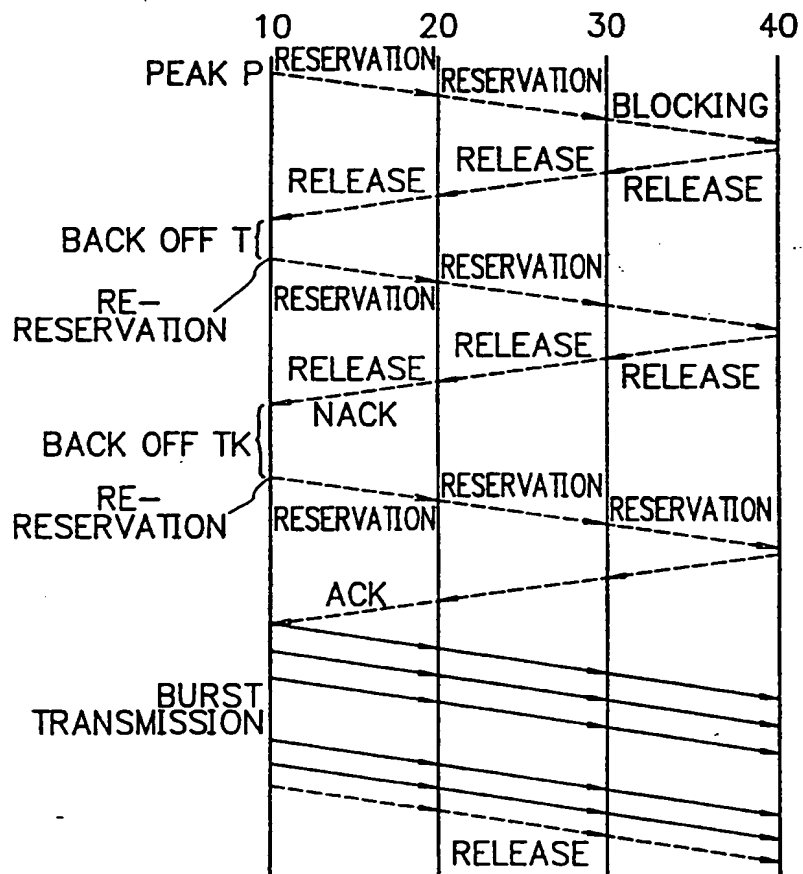


FIG. 7

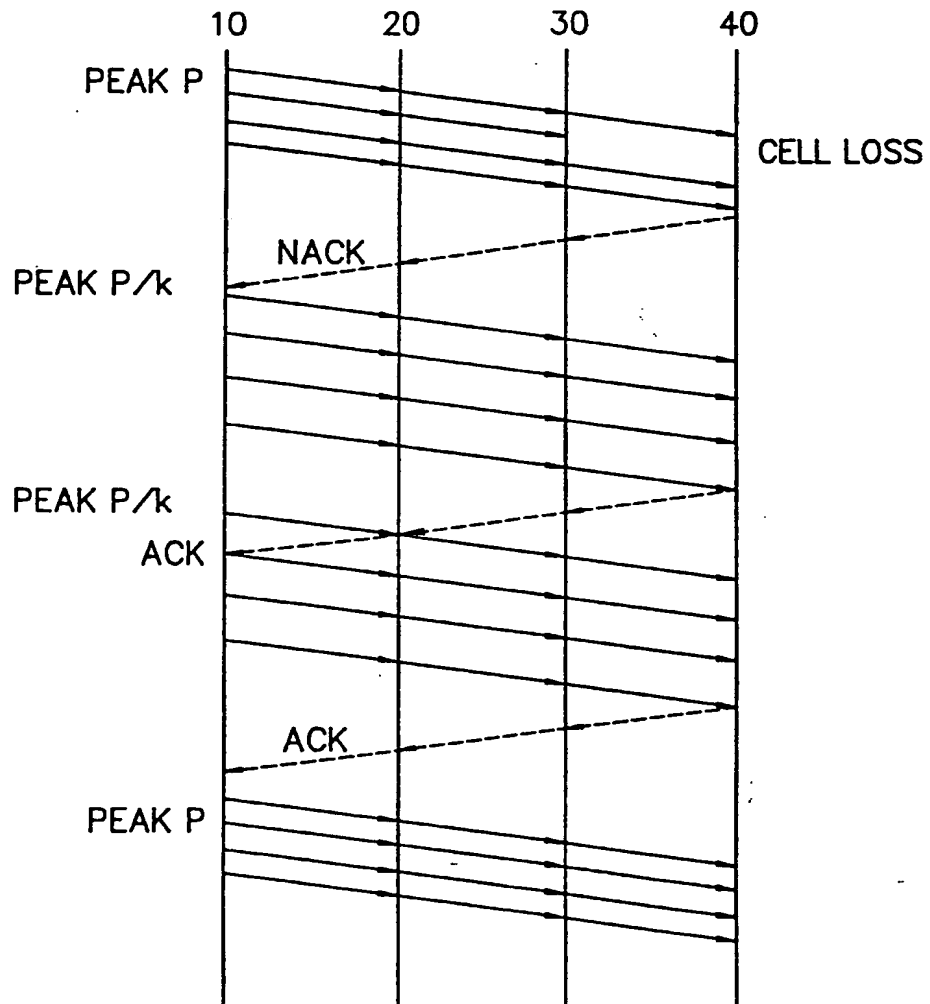


FIG. 8

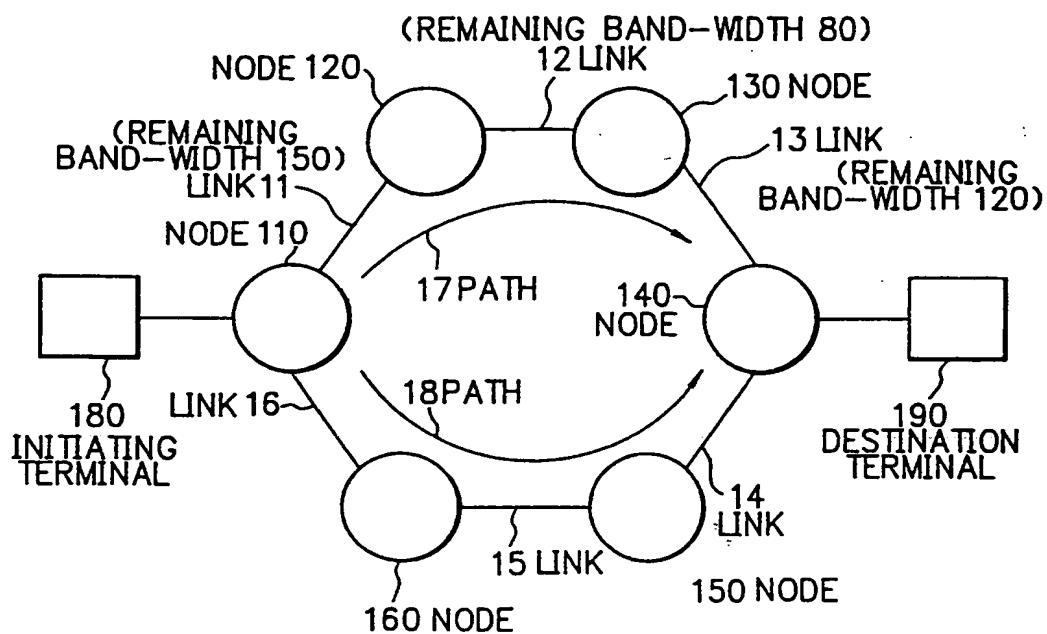


FIG. 9

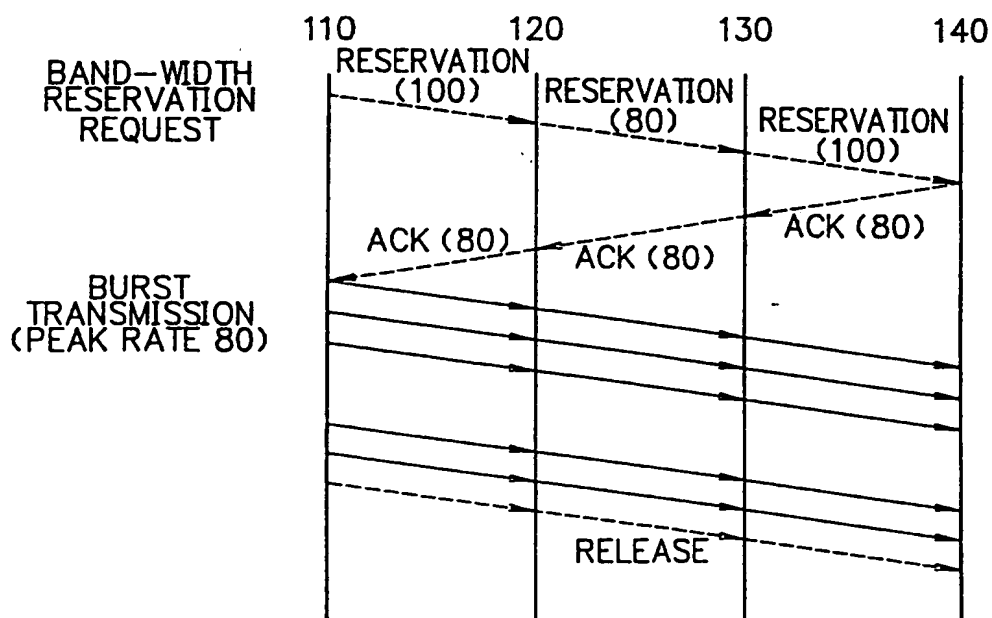


FIG. 10

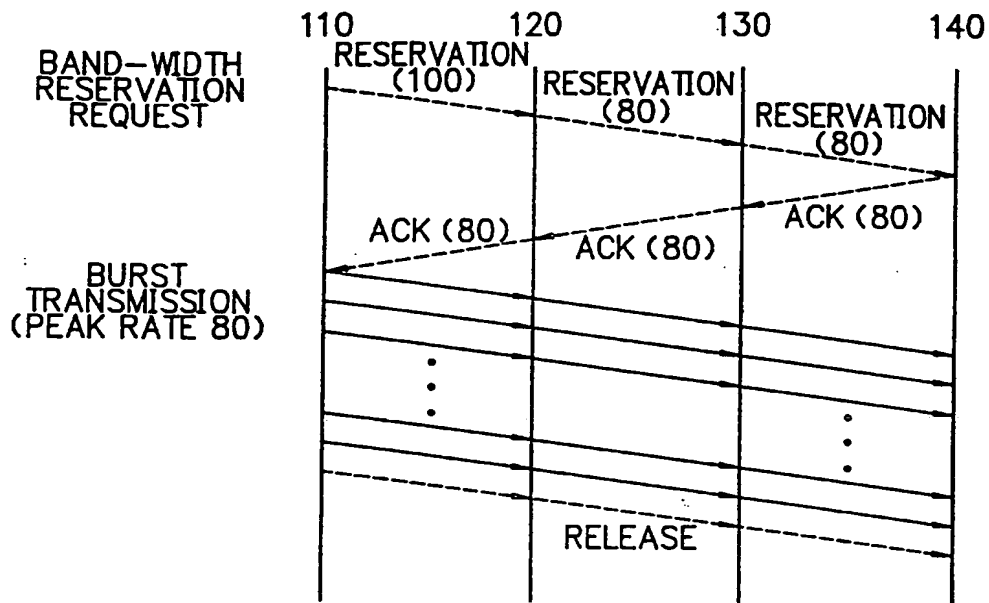


FIG. 11

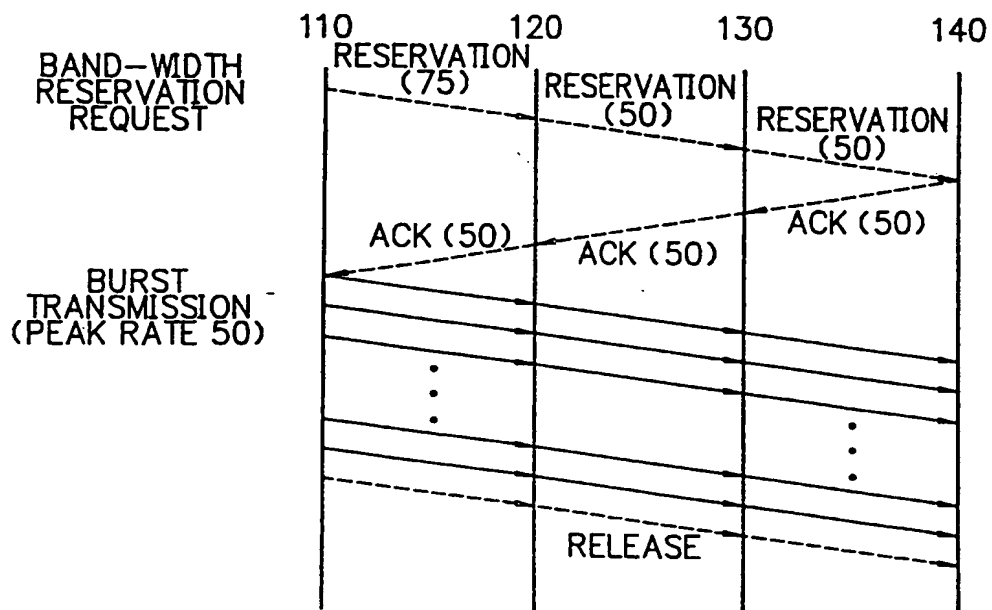


FIG. 12

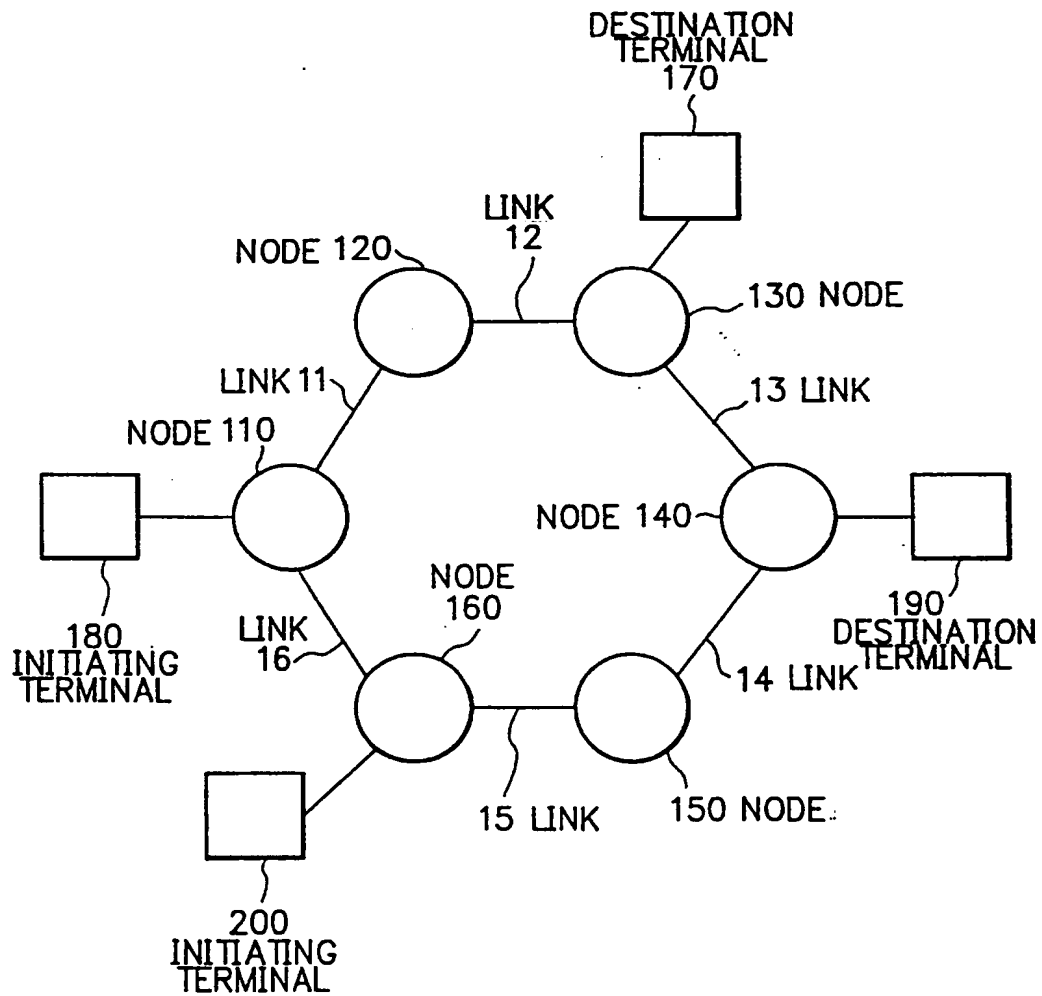


FIG. 13

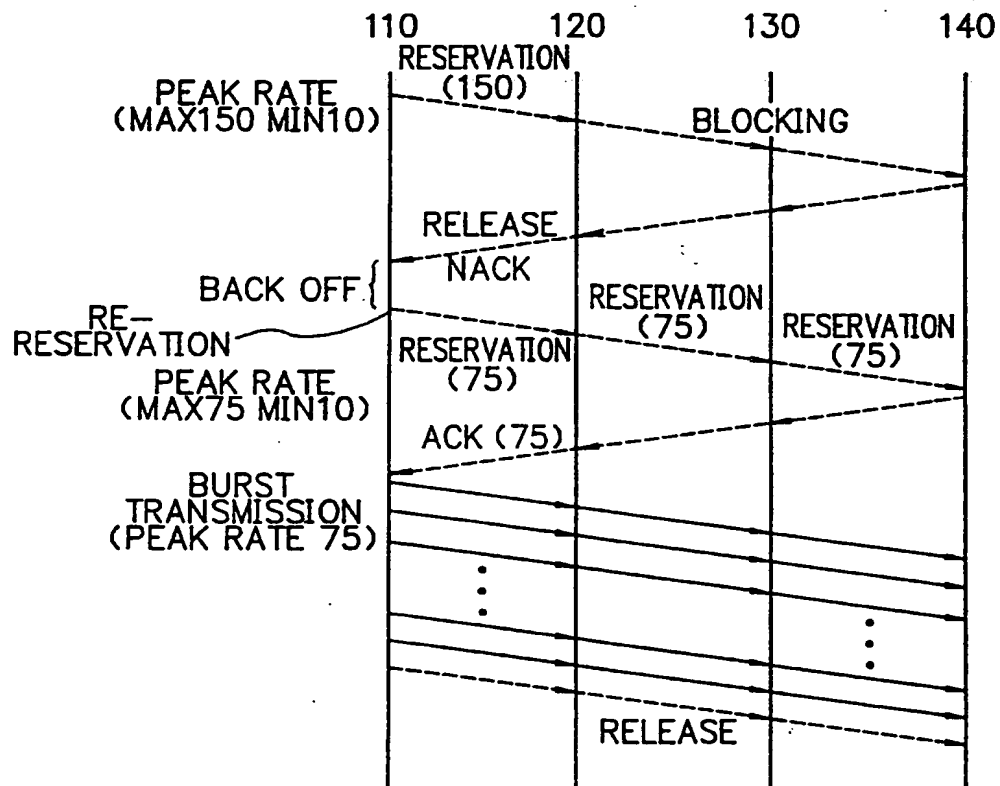
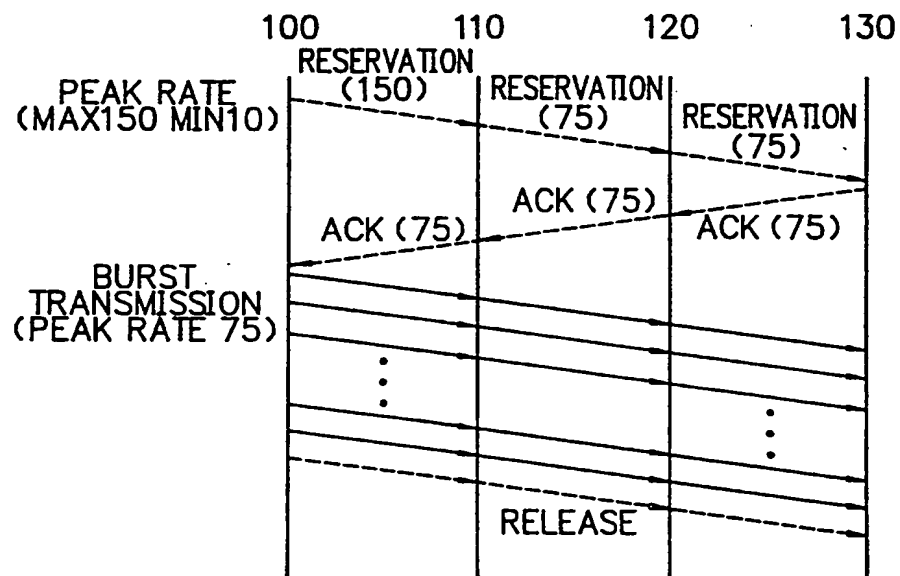


FIG. 14



(19)



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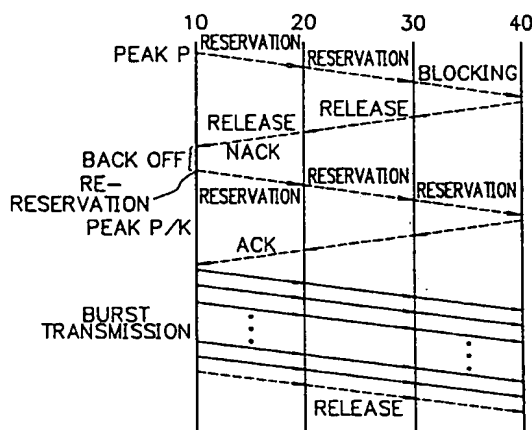
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(54) **Burst band-width reservation method in an asynchronous transfer mode (ATM) network.**

(57) In an ATM network using a burst-level band-width allocation, a source terminal reserves, before a burst transmission, band-widths according to a peak rate of the burst and then sends the burst therethrough. When the transmission is finished, the band-widths are released. Where there exists a link to which the peak rate is not assigned, NACK is sent to the terminal and the reserved band-widths are released. On receiving the NACK, the terminal allocates a band-width with peak rate lower than that of the first request after a back-off time is elapsed, thereby minimizing the block probability of the transmission. The source terminal declares a minimum band-width together with the peak rate (maximum band-width) in the band-width request operation. Each node allocates the peak rate when the remaining band-width of a link controlled by the node is sufficient to allocate the peak rate. Even if the remaining band-width is insufficient, when the band-width is not less than the minimum band-width, there is allocated a band-width equal to or more than the minimum band-width and equal to or less than the peak rate according to the remaining band-width, thereby transferring the burst.

FIG. 3**EP 0 609 654 A3**



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EUROPEAN SEARCH REPORT

Application Number
EP 94 10 0115

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
A	EP-A-0 448 073 (FUJITSU LIMITED.) * claims 1,4 * ---	1-6,9	H04L12/56 H04Q11/04
A	IEEE INTERNATIONAL CONFERENCE ON COMMUNICATIONS, vol.2 OF 4, 15 April 1990, ATLANTA pages 439 - 442, XP000169724 WANG ET AL. 'Bandwidth Allocation for ATM Networks.' * page 440, left column, line 34 - right column, line 42 * ---	1-6,9	
X	EP-A-0 446 956 (FUJITSU LIMITED) * column 2, line 4 - line 17; claims 1-3 * -----	7,8	
			TECHNICAL FIELDS SEARCHED (Int.Cl.5)
			H04L H04Q
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 11 August 1994	Examiner Veen, G
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application I : document cited for other reasons & : member of the same patent family, corresponding document			



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CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

- ☐ All claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for all claims.
- ☐ Only part of the claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid, namely claims:
- ☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirement of unity of invention and relates to several inventions or groups of inventions, namely:

See sheet -B-

- ☒ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.
- ☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:
- ☐ None of the further search fees has been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:



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EP 94 10 0115 -B-

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirement of unity of invention and relates to several inventions or groups of inventions, namely:

1. Claims 1-6,9-12: Bandwidth reservation method based on counting the number of failed or successful reservation attempts
2. Claims 7,8 : Bandwidth alteration method based on the number of successful or failed actual transmission